Project Experience

Bi-directional O-Cell® testing of Metro Foundations

Fugro LOADTEST have been performing O-Cell® tests for Mass Rapid Transit foundations for more than 30 years and have participated directly in some of the most challenging projects globally. From metro stations in fastest-growing countries to complete metro lines in one of the most populated cities in the world, Fugro Loadtest was there to provide all the advantages of O-Cell methodology.

The O-Cell method of testing the foundation capacity of piles used for metro foundations provides numerous advantages over traditional top-down loading arrangements. A key benefit of using bi-directional testing is the elimination of additional anchor piles or external reaction systems, employs a small footprint and little or no headroom needed and without the need to bring the concrete of the pile to piling platform level.

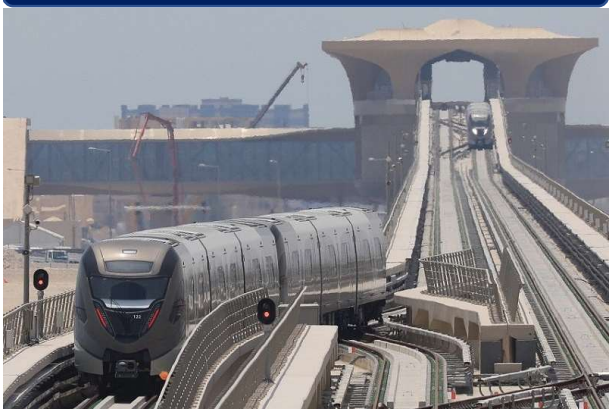
As the technology for drilled shafts/piles develops and larger loads are demanded from each foundation element, the need to verify these design capacities increases. Loads applied using the O-cell method often exceed 50 MN and can easily be applied to preliminary test piles or working piles.

The following examples are just a small selection of some of the world class Metro projects that have successfully used O-Cell technology to test the foundation elements.

Lima Metro Line 2 – Peru

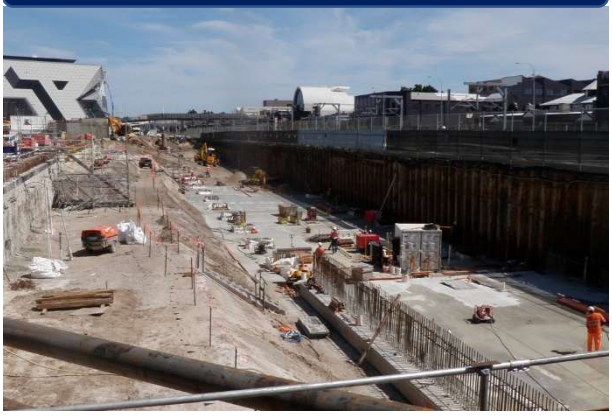
The Lima Metro project is an important investment for the Peruvian government to improve the mobility of people around the capital. The project started in 1980 with Line 1 and expanded with Line 2, a 27 km underground line linking the district of Ate and the Callao region. Fugro Loadtest periodically performed O-Cell testing at stations along the line to characterize the geology, typically loose gravel underlined by dense gravel and optimise the foundation design.
Seven 1800 mm diameter test piles with lengths between 18 and 32 metres were performed, mobilizing capacities from 49 MN to 70 MN.
An additional 2 test piles, with depths of 42 and 51 metres, were performed later, and as expected, revealed higher capacity than design expectations. SONICaliper shaft profiling was also executed in these pile shafts before installation of reinforcement and concrete.

NDIA Metro Terminal Station – Qatar



As part of a huge Qatari investment ahead of the world cup this project was to connect the city of Doha to the New Doha International Airport (NDIA), a $7 million metro line was designed, including a 1.3 km single track, twin bored tunnels and a 20 metre deep cut-and-cover underground station.
To obtain geotechnical information necessary to verify and optimise the foundation designs, five piles were tested with the O-Cell method.
Three Ø1,200 mm working piles were tested as push-out tests simulating pull-out tests to reveal the skin friction directly and tested to 14 MN.
Two conventional O-Cell tests were also carried out in Ø1200 mm and Ø1800 mm test piles to loads of 10 MN and 15 MN, respectively.

Perth City Link – Australia



The Perth City Link project consists of "sinking" the rail line and the Wellington Bus Station to create a 13.5 hectare space that will be used for housing and business.
Load tests were carried out on bored cast in-situ piles and barrettes with the use of the O-Cell method. At the base of the foundation elements, Stiff Clay Guildford Formation layers and Kings Park Formation layers were found.
The test piles were constructed with a diameter of 1050 mm and depths up to 45 metres. The barrette test was performed on a 2,400 x 600 mm panel, 20 metres deep.
The test results allowed the client to confirm the construction quality and verify the settlement behaviour at serviceability load.

Riyadh Metro – Saudi Arabia

The Riyadh Metro is a rapid transit system under construction in Riyadh, the capital city of Saudi Arabia.
It is part of the King Abdulaziz Project for Riyadh Public Transport and will consist of six metro lines spanning a total length of 176 kilometres (109 mi), with 85 stations. The project will cost $22.5 billion to build. It is expected to open to passengers in 2024.
As part of the construction works on Line 6.3, Fugro Loadtest were commissioned by the FAST Consortium to undertake full scale bi-directional O-Cell loading tests in a multilevel arrangement deployed in a 20 m deep 1200 mm diameter test pile was fitted with two pairs of 330 mm O-Cells which allowed the interpretation of the skin friction and end bearing to be determined as 40 MN.

Singapore MRT – Singapore

The S$5 billion Mass Rapid Transit North East Line (MRT-NEL) has been one of Singapore's largest transportation infrastructure improvement projects, encompassing some 20 km of primarily underground track, 16 new stations and a new depot. Fugro Loadtest performed O-Cell tests for 4 separate contracts, including the C701, C710, C711 and C706. Since then the MRT has continued to be developed.
At the site of the Senkang Depot and Maintenance Yard (C701), tests were carried out on 14 preliminary test piles and on 19 production piles. Piles ranged in diameter from 1200 to 2400 mm with a maximum applied load of over 125 MN.
The Senkang Depot was also the site of a side-by-side comparison between the test results of O-Cell and Kentledge methods. Load-movement relationships for the two showed excellent agreement.

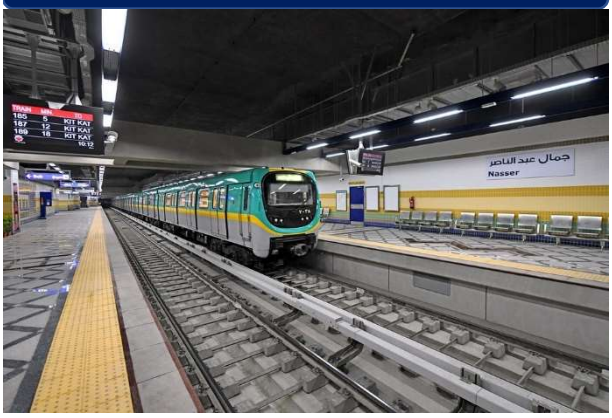
Elizabeth Line – United Kingdom

To connect the suburbs on the west and east of London, the British government funded the construction of a new underground railway system to improve the mobility of the commuters called Crossrail.
On one section of the new line, two test piles of 600 mm diameter and depths of 33 metres and were successfully tested alongside a live and operational existing underground line and with the equipment no higher than 1 m above ground level.
In a separate section, a Ø2100 mm 31.63 metres deep pile was tested up to load of 17.92 MN. All the piles were tested without the need to use external reaction frames, solving the space problem characteristic of this project in a highly congested central London. After the completion of the tests, the area around the O-Cell assemblies on the working piles was grouted to reinstate the structural continuity.

Golden Horn Crossing Bridge – Turkey

With more than 15 million people, the city of Istanbul has been investing in improving the public mobility. For the planned new metro line connecting Taksim and Yenikapi, a new 387 metre-long steel cable stayed bridge was planned for the Golden Horn area.
The project required the testing of 1 preliminary pile on land and 2 working piles, 90 metres off-shore, with the client choosing O-Cell methodology due to practical, economic and technical benefits.
The Ø1000 mm and 39.5 metre deep preliminary pile was successfully loaded to above the planned 36 MN. The Ø2200 mm, 85.5 metres deep working piles were loaded up to 47 MN and 65 MN.
This project could not have been undertaken by traditional top-down methods and proved again that the O-Cell method is the ideal method of load testing of rock sockets, both on-shore and off-shore.

Greater Cairo Metro Line 3 – Egypt



With a total length of 30 km, the Metro Line 3 is an important piece of the mass transit system in Greater Cairo. To fully characterize and understand the geotechnical behaviour of the founding stratum, two test piles were executed using O-Cell methodology.
One of the piles was tested as a single level test while the other was a multi-level test. The founding strata consisted mainly of silty sand and sand. The single level test was executed in a Ø1500 mm, 31.2 metre deep pile with the applied maximum gross load reaching 15 MN.
The multi-level test was executed in a Ø2400 mm, 40.7 metre deep pile with the maximum applied gross reaching 28 MN.
The results were analysed using the Cemsolve® pile settlement analysis program to determine the foundation behaviour and confirm the design parameters.

The Palm Monorail - Dubai

The Palm Jumeirah or Dubai Monorail is Palm Jumeirah's monorail transit system designed by Hitachi. The monorail system is designed to serve the total length of Palm Jumeirah. Launched in 2009, it is the first to be installed in the Middle East and the first guided transportation system to be operated in the UAE.
The automated Palm Jumeirah Monorail System is operated and maintained by Serco Group plc, the same company that operates and maintains the Dubai Metro under the aegis of the RTA.
Fugro Loadtest were commissioned to perform an O-Cell bi-directional test on a 1500 mm diameter 25m deep working pile which was loaded to 35 MN at the proposed Trump Plaza Station. Post test grouting was carried out to restore the structural integrity of the pile.

Copenhagen Metro – Denmark

The Copenhagen Metro has four lines M1, M2, M3 and M4 and Fugro were asked to assist with bi-directional static load testing on the extension of the M4 line from Copenhagen Central Station (København H) to Ny Ellebjerg (later to be renamed København Syd).
The Copenhagen Metro is designed to have departures every 90 seconds at peak times, running 24 hours a day, 7 days a week.
A single 1500 mm diameter pile, bore 16.5 m from piling platform level was designed for the test. The area of concern for the loading was the limestone layer beneath the clay overburden. Since only the rock socket was of importance, the upper 11.0 metres of the bore was left without concrete and backfilled with sand, allowing all the 28 MN test load to be applied directly at the zone of interest.